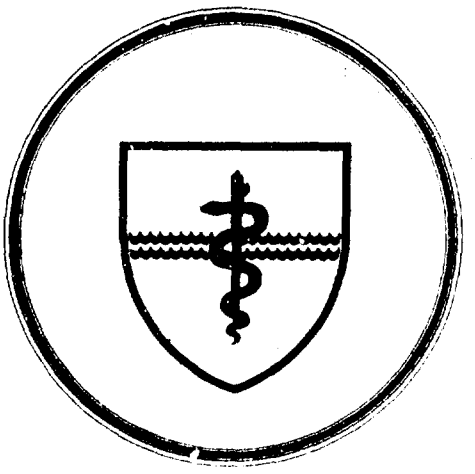
NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

SUBMARINE BASE, GROTON, CONN.



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HISTORY OF MILITARY PSYCHOLOGY

at the

U. S. Naval Submarine Medical Research Laboratory

by

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Benjamin B. Weybrew, Ph. D.
Head, Personnel Research Department, NSMRL, (1955-1979)

SUMMARY PAGE

THE PROBLEM

To present a descriptive chronicle of events associated with the development of the Submarine Psychology Program at the U. S. Naval Submarine Medical Research Laboratory (NSMRL).

FINDINGS

The operational requirements of the diesel submarines of WW II and, since the mid-fifties, the nuclear submarine service appear to have dictated the research areas focussed upon by the 15 or so military psychologists assigned to NSMRL. Upward of 500 scientific papers in the areas of vision, hearing, human factors, and personnel selection have been published by the NSMRL staff psychologists since the official establishment of the Laboratory on June 25, 1946. Substantive findings emerging from this psychological research have served to significantly improve the adaptability of submariners to long submerged missions.

APPLICATIONS

This historical account points out the fact that the intrinsic relationship between submarine operational requirements and the channelling of research effort to meet these requirements, has been, and still is an ongoing process, particularly insofar as the program in Submarine Psychology at NSMRL is concerned.

ABSTRACT

Largely mandated by the operational requirements of the diesel submarine service of WW II, considerable psychological research in the areas of hearing, vision and personnel selection was conducted prior to the official establishment of the Naval Medical Research Laboratory (NMRL) on June 25, 1946. During the first decade of NMRL, the original staff of 9 psychologists doubled in size while producing some 80 scientific publications dealing largely with sonarmen's performance, visual problems of submariners and various aspects of the submariner selection problem. Ushered in by the launching of NAUTILUS, the first atomic-powered submarine in 1954, the nuclear era brought with it many new psychological problems associated with the increase in the duration of submerged patrols from 3 to 80 days or more. Psychopathological effects of isolation, increased auditory and visual skills requirements, and a host of human factors problems associated with complex nuclear technology are examples of the content of the some 550 papers published by the NSMRL staff psychologists in the fifties and sixties. Based upon a presumed leveling off of advancements in nuclear submarine technology for the present, changing research foci in the psychological program at NSMRL are predicted. One trend thought likely is for less focussed work in the areas of auditory and visual perception and more emphasis upon matters related to the psychiatric screening of submariner candidates as well as investigative efforts to discover new approaches for the prevention of morale deterioration, performance decrements, and in some cases, debilitative psychopathology in submarine crew members during long submerged missions.

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at the U. S. Naval Submarine Medical Research Laboratory

INTRODUCTION

The Submarine Medical Research Laboratory as a separate command of the U. S. Navy has evolved over a period of 37 years with its roots extending from the war years in the 1942 to 1945 time frame. The Naval Submarine Medical Research Laboratory (NSMRL) as it is presently called stands as an outstanding example of the processes by which an in-house research organization has developed in response to the operational requirements of a fast-developing branch of the military, the Submarine Service. Starting with the holocaust of Pearl Harbor, the military importance of submarines within the nation's armamentarium has skyrocketed. This new visibility of the submarine service has occurred largely because of the technological advances extending from the diesel submarines in WW II through the prototypes of the nuclear-powered "subs" of the fifties to the nuclear attack (SSNs) and the nuclear ballistic missile submarines (SSBNs) of the sixties and seventies. Correlated with such technological breakthroughs as the development of the nuclear-propulsion plant for the NAUTILUS, the first nuclear submarine, were gigantic increases in the environmental demands imposed upon the submarine crewmembers. Some of these changes had to do with the fact that the maximum duration of submerged missions increased from 3 to 70 or more days, the crew had doubled in size and at the same time the skills levels and specialization requirements for each man had increased tremendously as a result of the advanced technology associated with the nuclear submarine.

The following chronicle then consists of historical "bits and pieces" intended to demonstrate in a small way the changing roles of military psychologists that paralleled the lightning expansion of submarine technology in the past 3 decades.

Submarine Psychology During WW II (1942-1945)

Dating back as early at 1942 and extending through 1945, a modest program of psychological research was carried out by a staff of 4 or 5 psychologists with 6 to 8 support staff, some military, some civilian. Until 25 June 1946 at which time the Medical Research Laboratory (MRL) was officially established, the research department functioned as an organization entity attached to the Medical Department of the Submarine Base, New London, Connecticut.

The prime actuator behind the psychological research program that evolved slowly prior to and during the war years was Captain Charles W. Shilling (MC) USN, a submarine medical officer. Captain Shilling, a broadly-trained physician, headed the Submarine Escape Training Program as well as the submariner medical examination section during this period. An example of Captain Shilling's breadth of interests and expertise is to be found in the fact that he was the first to demonstrate the relationship between pitch discrimination as measured by the Seashore Pitch Discrimination Test and sonarman performance on combat patrols (1.1*). In a recent (1979) tete-â-tete with Captain Shilling, still active as editor of the professional journal Undersea Biomedical Research, the discussion came to be focussed upon the difficulty of recruiting psychologists during WW II. He cited an anecdote to make his point. It seems that Captain Shilling requisitioned a $78 audiometer (he recalled the exact cost) from the Naval Bureau of Medicine and Surgery and, with this instrument initiated the sonarman hearing testing program in the early forties. Having gotten the hearing program underway, he began the difficult task of recruiting an auditory expert to run the program. His long quest ended when he followed up a lead that a PhD specialized in the auditory field was in a seaman's uniform at a nearby base. The offer of the auditory position at New London to the seaman/PhD was first made with the candidate holding a regulation, 2-pound (wet) Navy swab. First a commissioned officer and later a civilian scientist, this man, Dr. J. D. Harris, headed the auditory research program at NMRL for more than 30 years.

*The decimal codes refer to entries by time-segment found in the reference section of this paper.

During the same face-to-face chat with Captain Shilling in mid-1979, the topic of conversation switched to the relationship between the operating forces and research psychologists, both civilian and military. He related another "sea story" to make his point. The experiment conducted during the war involved the assessment of the visibility of different colored harbor lights. Following a busy night of data collection, the submarine flotilla commodore angrily called Captain Shilling to his office to get an answer to the question of who was responsible for leaving opaque hoods over half the lights in the harbor. This event was cited as an example of how a seemingly minor event can jeopardize rapport between scientists and the operations types.

A select few of the psychologists involved most actively in submarine research during the war years and who remained to plan the program that emerged with the establishment of the Naval Medical Research Laboratory in 1946 might be called the "founding fathers" or as we say in the Navy, the "plank owners". These were: J. D. Harris in the audition/sonar area (1.2), Dean Farnsworth in color vision (1.3), W. S. Verplanck in night vision (1.4) and N. R. Bartlett in personnel selection (1.5).

The emphasis upon research in the auditory, vision and personnel selection areas resulted from the nature of the diesel submarine in World War II. While submerged, WW II submarines were powered by electric engines energized from storage batteries with a usable half life rarely exceeding 8 hours. During submerged missions, the "eyes" of the submarine were the sonarmen's ears which received the undersea sounds, the basic information upon which the detection and recognition of enemy targets were based. To recharge the storage batteries used to propel the completely submerged submarine * it was necessary to abandon the relatively safe "run silent run deep" phase of the mission

* At the cost of compromising their concealment capability, diesel submarines could "run" partially submerged on diesel power with the schnorchel serving as an induction device for weather air.

and run on the surface for a period of 6 to 12 hours. In order to avoid detection, this battery-charging phase was usually carried out in the twilight hours or in the darkness thus requiring that the deck watch be comprised of men with maximum visual acuity at low illumination levels. As a result of these unique characteristics of the WW II diesel submarine, most of the wartime psychological research had strong personnel selection overtones, for example, methods of selecting sonar and night vision watchstanders, and approaches to the selection of submariner candidates with maximum capacity to adapt to confinement, isolation, crowded conditions, depth charging, and breathing stale air — to name a few stresses of the WW II submarine's mission.

The Ideological Roots of the Navy Medical Research Laboratory (NMRL)

Thus it seemed inevitable that the post-war research program that emerged with the newborn laboratory had its roots in the different programs functioning during those war years. The schematic in Figure 1 presents some of the ideological roots merging into the initial structure of the U. S. Naval Medical Research Laboratory (MRL) while Figure 2 depicts the original organizational design of the laboratory.

It is immediately apparent in Figure 1 that auditory research associated with the performance of sonarman and vision research in the areas of acuity, color perception and dark adaptation were core programs in the initial MRL structure. Another obvious point centers around the interrelationship of the training program in effect at the time (labelled "Instructional Type Problems" in Figure 1) with the personnel selection program designed to identify the men most amenable to such specialized training as sonar, night and radar watchstanders.

The mission statement in Figure 2 obviously encompasses a broad range of objectives including, by implication at least, any basic, applied or developmental research which has a high probability to yield findings bearing on the effectiveness of the submarine force. As will be seen in the chronology to follow, one result of

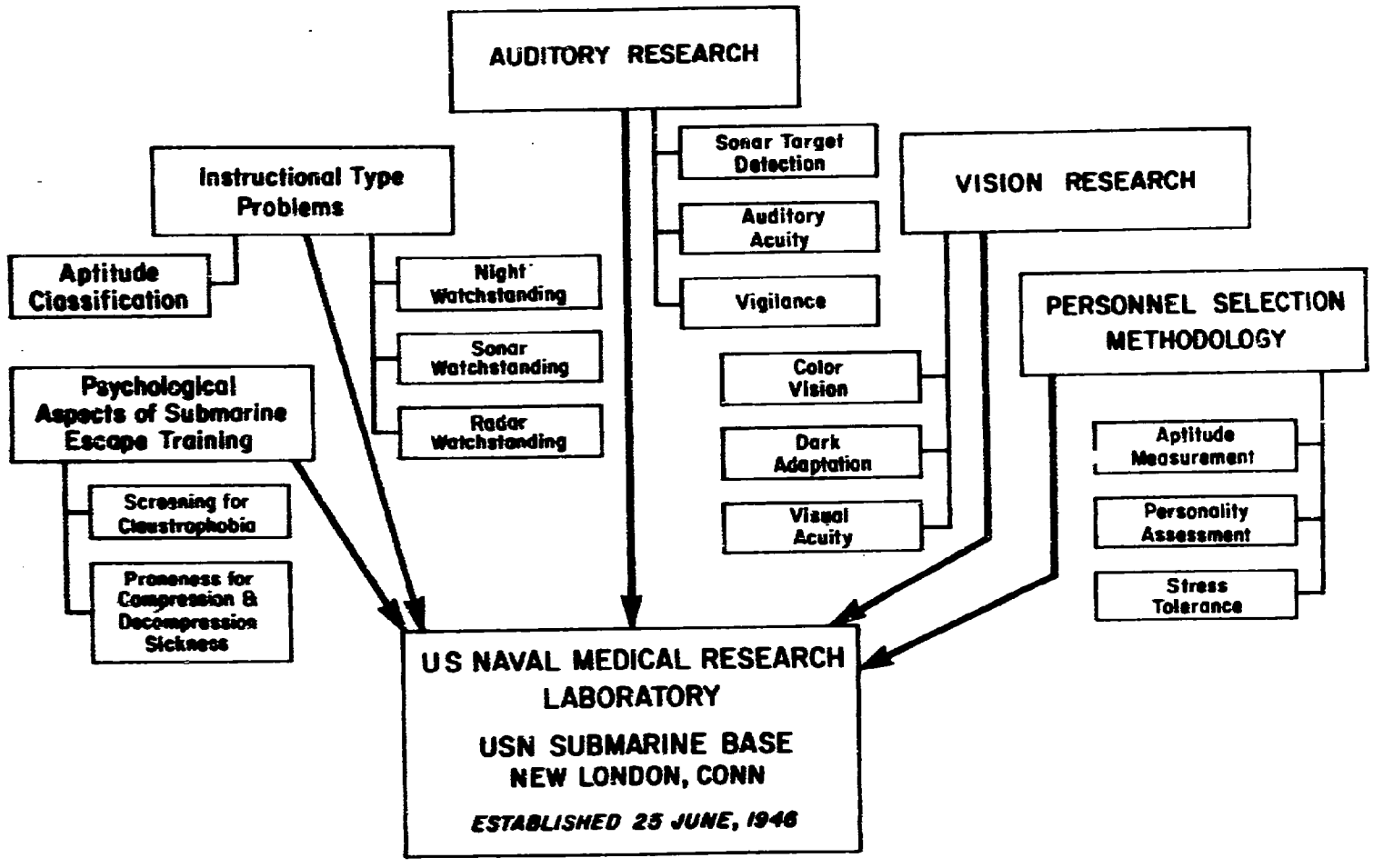

Fig. 1. The Roots of the Military Psychology Program at the U. S. Naval Medical Research Laboratory

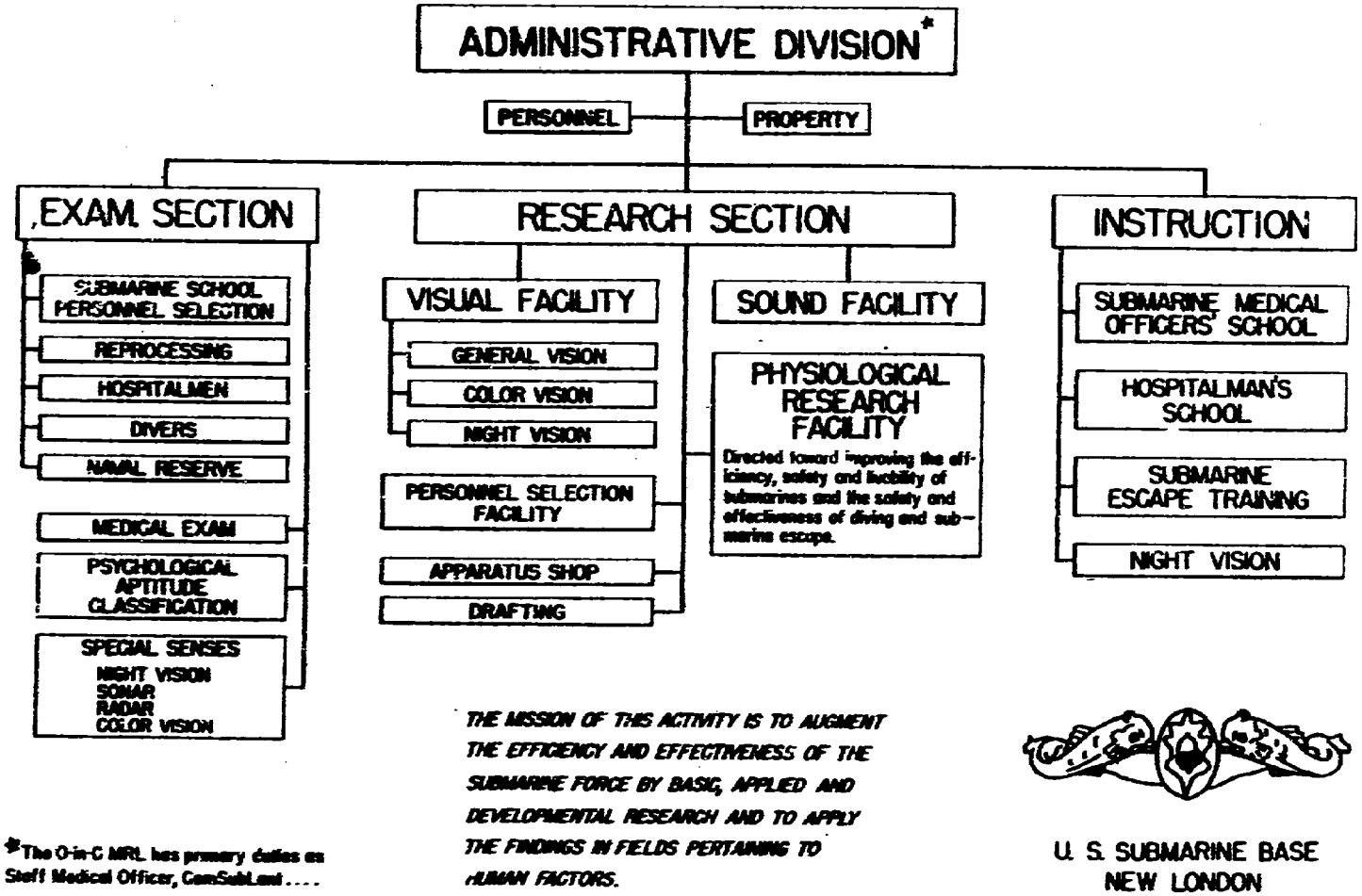

Fig. 2 - The original organizational structure and mission statement of the U. S. Naval Medical Research Laboratory.

the breadth of the initial program at MRL was the requirement that the staff psychologists were called upon to plan and implement a great deal of "broad brush" studies, particularly in the first 10 years or so. This research tended to be rather poorly focussed at times, the objectives being to sift through masses of variable interactions (physiological, psychological, biochemical and anthropological) in order to identify the major problem areas upon which to focus future programs.

After its formal establishment, NMRL became the responsibility of an Officer-in-Charge (O-in-C), a position to be occupied by a qualified Submarine Medical Officer with the rank of Captain: The first O-in-C of NMRL was CAPT Charles W. Shilling (MC) USN. The operating budget for FY '47 allocated by the USN Bureau of Medicine and Surgery was 100K. The number of psychologists in each of the three specialties on the NMRL staff during the first years of its existence were: in vision 4 PhD, 5 BA/MA; in audition 2 PhD, 2BA/MA, and in personnel selection 2 PhD, 1 MA.

The focus of the research program in the developmental years of NMRL was considerably influenced by the advice and counsel of several distinguished consultants among which were Henry Murray and Robert Bales of Harvard, Harvey Locke, University of Southern California and Robert Wherry of Ohio State University. During these formative years, the cadre of consultants met periodically in concert with the staff psychologists most often in the context of planning conferences held at NMRL. Examples of these were the Sound Conference held in June, 1945 (1.5) and the conference on submariner selection organized by an ad hoc committee appointed by the Surgeon General in April of 1952 (1.6).

NMRL - Pre-Nuclear Era (1946-1953)

Following the end of WW II in 1945, the role of the staff military psychologists at NMRL became more diversified. The major impetus for this diversification of research effort was a technological "giant step", a spinoff from the atomic bomb, namely the development of the nuclear propulsion system for the first atomic-powered submarine, the Nautilus. In the late forties, prior to its keel-laying on June 14, 1952,

the Nautilus planners began to leak hints of anticipated problems, many of which involved questions related to man's capacity to adapt to the rather harsh demands imposed by the nuclear system. For example, since oxygen is unnecessary for the nuclear engines, nuclear submarines can remain submerged almost indefinitely, the duration being limited only by the amount of food, oxygen, and other vital essentials that could be manufactured or transported. A somewhat trite expression making the rounds in those days gets to this point, "Nuclear subs need only to surface every four years for the men to reenlist!"

Thus, in the late forties, questions were being raised regarding the likelihood of significant psychological problems occurring as the result of much deeper and longer-duration submerged patrols, accumulative effect of toxic contaminants in the atmosphere, larger crews (50 to 100 percent increase over WW II "subs"), isolation and confinement and the removal of day/night cues — to list a few of the stresses of nuclear submarine duty.

Accordingly, the psychologists at the newly-founded NMRL modified the research program to focus upon some of the questions raised during the planning and fabrication phases of the Nautilus. For example, since most of the control switches and buttons on the submarines were color coded, a screening test to identify color perceptual deficiencies within the input population of submariner candidates soon became a critical requirement. The well-known Farnsworth Lantern was developed, validated, field-tested and patented to meet this requirement (2.1).

A second critical need of the nuclear force, actually involving an interacting set of complex requirements, had to do with finding answers to one of the questions cited above, namely the one related to a submariner's capacity to adapt to submerged patrols, several months in duration. An example of the criticality of these questions passed on to the Officer-in-Charge of NMRL for prompt answers late in 1952 may be inferred from the tone of a letter, dated August 1, 1951, from the Chief, Bureau of Ships, to Chief, Bureau of Medicine and Surgery. In a capsule, the letter stated that if the answers to questions such as possible toxic effects of the atmosphere

and adverse psychological effects of isolation and confinement during long patrols are not answered, Nautilus will be the only nuclear submarine constructed. To quote, "it will quickly become an endangered species."

Under this kind of pressure, the staff of NMRL quickly designed a multi-disciplinary experiment (an all-hands evolution in Navy language) designed to answer these critical questions. The most all-pervasive of these questions had to do with the accumulative psychophysiological effects of exposure to carbon dioxide (CO_2) at about 1.5%. Briefly, 23 submariners were incarcerated in an evacuated submarine for 60 days, 46 of which involved CO_2 at 1.5% with 7-day pre- and post-experimental control periods (normal CO_2 levels = .03%). The summary of the psychological findings (2.2) mentioned only slight changes in visual and auditory perception, and in psychomotor function. Similarly, reported also was slight deterioration in the motivational and emotional status of the men, but no changes severe enough to suggest unequivocally debilitative effects of isolation, or of CO_2 exposure at this concentration and for this time duration. Accordingly, as a result of the largely negative findings of Operation Hideout as this study came to be called, construction of nuclear submarines was continued.

It was during Operation Hideout that the staff psycholigists at NMRL first learned of the importance of clear communication pathways with the press. For DOD laboratories especially, the P. I. (Public Image) Factor, i.e., the applied value of research outcomes of DOD-supported R&D Laboratories as conveyed by the news media, is most critical. A cogent example of how an inadvertently released news item snow-balled into foot-after-foot of newsprint on the front pages of several large newspapers follows.

During a press concerence midway in the 60-day Operation Hideout experiment, the Officer-in-Charge (O-in-C) was asked by a reporter if there were any remarkable changes in the behavior of the 23 submariners incarcerated in the high-CO_2 environment for more than a month. The O-in-C's reply expressed the opinion that no unusual behavior had been observed; however, there could be some changes in food preferences. Asked the reason for this possibility, the answer

was given that for four successive days he (the O-in-C) had approved requests from the cook/subject on Operation Hideout for cottage cheese for the subjects. There is the remote possibility, continued the O-in-C, that a calcium deficiency had developed from the combining capacity of CO_2 to "take up" calcium in the blood. Rich in calcium, cottage cheese could be satisfying this deficiency. As it turns out, one of the 23 submariners serving as an experimental subject had requested cottage cheese on day one. It was ordered but was not available on the central supply shelves. The same order was re-submitted but went unfilled on days 2 and 3 but finally was negotiated on day 4.

Before the press could be contacted to clarify the story, the following screaming headline with many feet of correlated print appeared in the major papers across the USA: "Incarcerated submariners develop an insatiable desire for cottage cheese". Furthermore, the supporting text pointed to CO_2 exposure as the unquestioned cause of the appetite change. Calls from blood ion and blood gas experts, toxicologists, and dentists concerned about decalcification of teeth were frequent the next few days. Moreover, not unexpectedly, several local dairies offered free cottage cheese in truckload lots for the Hideout subjects.

As the history of most sciences shows, methodological breakthroughs often greatly affect research foci. For example, subsequent to the publication of Thurstone's "Multiple Factor Analysis" in 1947 and Stephenson's book on Q-technique of factor analysis in 1953, several of the NMRL staff applied factor analytical techniques (a) to the problem of identifying major psychophysiological response patterns correlated with individual differences in the stress tolerance of submariners (2.3), (b) to the problem of delineating significant adjustment criteria (2.4), and (c) somewhat later, to the task of extracting the most relevant primary auditory abilities within the submariner population (2.5).

NMRL - The First Decade of the Nuclear Submarine Era (1954-1964)

1954-1957

The Nautilus, the first nuclear-powered submarine, was commissioned September 30, 1954. The prospect of groups of 100 to 140 men being confined to a steel tube the length of a football field for 50 to 100 days taken in the context of the findings dealing with the effects of stimulus impoverishment reported about the same time by the McGill group served to channelize the research during the first triennium of this period (1954-1957). For example, focussing first upon the stimulus aspects of the isolation problem, led to empirical determination of optimal standards for red lighting on subs (3.11). The results of these and other studies yielded firm criteria for optimizing the dark adaptation process in red light thus enhancing the effectiveness of periscopic viewing under low illumination conditions.

The criticality of sonarmen performance involving vastly more complicated sonar hardware also received attention during this time frame. One aspect of this problem was specifically focussed upon during this period, namely, the question of potential hearing loss resulting from long exposure to sound levels considerably above normal (3.12, 3.13).

Field studies aboard the Nautilus were also conducted during this period (3.14). Taken together, these studies might well have been described as "brush fire" research, in that the questions to be answered were alleged to be critical for the operational effectiveness of the submarine service at the time. One such many-faceted problem had to do with identification of the causes of such obscure symptomatology as headaches, blurred vision, dizziness, malaise, and performance decrements reportedly occurring in a majority of the Nautilus crew within 72 hours after submerging. While not wholly conclusive, the findings based upon data collected during the 14-day submerged voyage of Nautilus, the longest "sub" mission at that time (1956), tended to exonerate airborne toxins in the ambient atmosphere of the "sub" as a major etiological agent.

In addition, perceptual abnormalities resulting from stimulus reduction as suggested by the McGill research were not found in these studies.

Recognition by the NMRL research planners of the critical requirement for the development of a submariner selection test battery appeared to have occurred during this period. As a start, an experimental psychiatric screening test (NMRL Report 290)* and a test of the motivational intensity of the input population of submariner candidates (4 to 5 thousand annually) were developed and field-tested at that time (NMRL Report 321). In addition, a battery of selection tests for sonar operators was developed and preliminary validation data obtained about the same time (NMRL Report 288).

1958-1961

This time frame in the history of the nuclear submarine service might be described as the advent of the nuclear armed missile into this branch of the military. For the NMRL psychologists it also meant the introduction of the two-crew concept, Blue and Gold, with all of social psychological problems associated with two interdependent groups of 140 submariners each successively occupying the same submerged habitat for periods up to 90 days.

From its beginning the only all-volunteer branch of the military, the submarine service, mainly because of the doubling up of the much larger FBM (Fleet Ballistic Missile) submarines, began to feel the pinch of shortages of qualified men recruitable in sufficient numbers from the young male population. Delineation of the attitude patterns which characterize the highly-trained nuclear submariners who opt for full retirement careers was the major research objective of one control group study (submerged crew versus matched shore-based control group (3.21). One of the ancillary findings from this study suggested that any supportive measures that prevented ego or self esteem attitudes

* The referencing format is slightly modified from here on out to include additional key papers. Titles, authors and AD codes for these publications may be obtained from the Publication Office, NSMRL (Code 814), Box 900, USN Submarine Base, Groton, CT 06340

from becoming negative during long submerged patrols would be effective for sustaining individual motivation and group morale underway.

With the launching of the first FBM, the George Washington in 1960, the urgency for an empirical determination of the maximum duration a submarine could remain submerged before debilitative symptoms appeared in significant proportions of the crew became even more apparent. As is often the case in DOD (Department of Defense) Laboratories, certain research, particularly field research, is often accomplished most economically by the "piggy back" approach, an example of which follows. The TRITON, the only twin reactor submarine ever constructed, was launched August 19, 1958. As a shakedown cruise two years later, Captain Edward L. Beach was ordered by the President of the United States to circumnavigate the globe and in so doing trace Magellan's path. Not only was the purpose of this 84-day submerged mission to evaluate the nuclear propulsion system of the Triton, but also to obtain reliable gravimetric data from a stable platform (the submerged submarine), to be used for launching and controlling the first U. S. space capsule, a project that had been receiving the highest priority since Sputnik I was placed in orbit on Oct 4, 1958. Again, the staff psychologists of NMRL were asked to organize a family of interrelated studies designed to assess the psychological effects of an 84-day submerged mission.

Published finally in the open literature more than 10 years later, the results tended to support the general notion that an optimal SSBN patrol length would most likely be in the 60- – 70-day range (3.22). This study yielded at least one serendipitous finding, an hypothesis with at least heuristic value, which was observed in plots of indices of group morale as a function of days submerged. Stated simply, significant peaks in the morale curve appeared during each of the 24-hour periods during which "periscope liberty" was granted for the crew. It was hypothesized, that allowing men to line up for a few seconds of periscope viewing of the sea, a landfall, a cloud or a bird in flight provided a "cognitive anchor"—reassurance that there was still a real world out there.

One other publication similarly delayed in publication for more than 10 years was a voluminous report of a factor analysis of a very diverse battery of some 180 measures of indices obtained from a sample of 120 submariner candidates (3, 23). Labelled the 17 Ketosteroid study at the time the data were collected in the late forties and early fifties, the study yielded some 50 descriptive factors delineated by patterns of hormonal, hematological, cardiopulmonary, psychometric and anthropometric indices. While never validated, these factors were presumed to be usefully predictive of individual differences in the stress or SNAFU tolerance of submariners.

A wide range of briefer studies with both applied and basic features were completed during this interval. Some examples are: a night vision test was standardized and patented (NMRL Report 342); an investigation of the biographical and emotional factors affecting performance in the submarine escape training tank (NMRL Report 329); an attempt to identify predictors of differences in navymen's adaptation to wintering-over in the Antarctic (NMRL Report 350); a controlled study of the effectiveness of a bowel-wetting type drug to control the last one of the legendary 3 C's of submariners (colds, catarrhal fever and constipation) in a crew during a long patrol (NMRL Report 305), and application of scaling techniques to the problem of establishing pitch intervals in sound stimuli (NMRL Report 353). The diversity of subject matter upon which the NMRL psychologists focussed during this interim was without question the result of the encouragement, support and counsel provided by the late Dr. Walter F. Miles who occupied the position of Scientific Director of NMRL from 1958 to 1966.

1961-1964

The program emphasis of the NMRL psychologists in this time frame appears to reflect recognition by the management in BUMED (Bureau of Medicine) of a broad, two-horned question highly relevant for submarine

psychology. Sometimes called the double fit question, "How does one go about optimizing the "fit" of the man to his environment and, conversely how can the environment be organized so as to provide the best "fit" to the man?"

As a start toward answering both parts of this question, a Human Factors Engineering Branch was established within NMRL early in this period. Three areas of emphasis were identified as sections in this research branch and were entitled Reaction Factors, Perceptual Factors and Systems Research. This particular division of labor resulted from a broad scope, comprehensive review of the rather narrow literature of human engineering peculiar to submarines (3.31).

Field studies employing time series designs were emphasized during this time frame. Collected mainly from the Patrick Henry, the second FBM,* a broad spectrum of data were obtained before submerging, periodically during the 60- 70-day patrols, and after surfacing, the latter data being collected to shed some light on post-patrol recovery processes. Partially summarized in one paper written in 1963 (3.32), the three additional papers written in 1962 focussed on the interrelationships of adjustment criteria (NMRL RPT. 282), upon the predictive power of biographical data with respect to these criteria (NMRL Rpt. 384) and upon the correlational patterns of aptitude and personality test scores with individual differences in quality of adaptation to long submerged patrols (NMRL Rpt. 388). In general, the results of this family of studies disclosed low but non-chance relationships between the adjustment criteria and age, marital status, amount and type of previous submarine experience, aptitude test scores and measures of emotional stability. Attitude change patterns during submergence appeared to be one of the most substantive sources of criterion information with respect to which various classes of submarine selection data could be validated.

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* Fleet Ballistic Missile submarine

A close examination of the research production during this interim provides copious evidence that the staff psychologists of NMRL were not only interested in answering research questions arising from the operational forces but also were interested in theory development in subject matter areas underpinning the applied program. Again, encouragement to proceed along theoretical lines came from Dr. Miles, Scientific Director, truly a constant among variables. An approximate quote from Dr. Miles' frequent discussions of this subject "No research has potentially more applied value than good, sound basic research!" Examples of this theoretical thrust in those days may be found in the theorization dealing with visual sensitivity at various spectral wave lengths (3.33), progress in an attempt to identify an international audiometric zero (3.34), and in an attempt to identify and describe some of the skeletal-muscular and autonomic reaction patterns underlying stress adaptation (3.35).

Dr. Miles also encouraged what he called exploitive field research, a term which he used to refer to research designed around real life events. An example of this type of field research was published during this period, the study consisting of a demonstration of the sharp increase in the belligerent attitudes of U. S. Navy submariners following the Cuban Crisis of 1962 (3.36).

Some 10 years after the founding of the Laboratory, several of the NMRL psychologists, generally those with substantial background in biology and physiology, began a collaborative effort with some of the Submarine Medical Officer staff to assess the behavioral effects of exposure of navy divers to exotic gas mixtures at very high pressure, at times as high as 20 to 30 times normal atmospheric pressure. For example, one study completed in the early sixties, reported slight changes in perceptual and emotional processes but no convincing evidence of debilitative performance

decrements in 3 divers exposed for 11 days to a hellum/oxygen/nitrogen "mix" in a pressure chamber at 7 times normal pressure (3, 37). Tending to support some earlier findings pertaining to submariner adaptability (NSMRL Report No. 416), certain of the data from this diver study tended to reaffirm the possibilities of using peripheral indices of autonomic function (e.g., electrodermal conductance) as a measure of individual differences in stress reactivity and tolerance.

NSMRL* - The Second Decade of the Nuclear Submarine Era (1965-1975)

1965-1968

One outstanding trend in the psychological program at NSMRL during this time frame was the appearance of "broad-band" research programs made possible by the introduction of high-speed, random access computers with enormous storage capacity. One example of this type of study was a rather specialized programming effort to computerize Navy diver decompression schedules. Labelled STANDIVE, this program has enhanced the safety of the Navy treatment procedures for compression sickness of various kinds (4. 11). Another example on a much larger scale was the Longitudinal Health Study (LHS) initiated during this time frame. The overall objective of LHS, a multidisciplinary effort, was to ascertain if exposure to the conditions existing during extended submarine patrols resulted in debilitative effects upon the general health of the crewmembers. While the data collection for the LHS began in this time interval, published reports based on these data did not begin to appear until 1974, one example being the presentation of normative visual data obtained from a large sample of submariners who had volunteered as subjects for LHS (4. 12).

It was during this period also that a group of NSMRL psychologists

*In July 1964, NMRL became a department of the Naval Submarine Medical Center. The "S" for Submarine was added to NMRL resulting in the laboratory's present title: Naval Submarine Medical Research Laboratory (NSMRL)

converged in a team effort upon the problem of improving the effectiveness of the 6- to 8-man teams tasked to fire the torpedoes and missiles comprising the weapons systems of modern nuclear submariners. Labelled the Weapons Systems Effectiveness Program (WSEP), this family of studies extended into the seventies. One type of problem investigated by the WSEP researchers had to do with communications overload in terms of the consequences for the quality of the solutions to representative fire control problems. In addition, a number of comparative problem-solving studies were carried out, for example, the efficacy of a computerized fire control solution of a tactical problem as compared to a triangulation-sliderule procedure called the "Wet Hen" technique, named after its developers, Wetmore and Henry, two British submarine officers. While most of the scientific reports emanating from this project were classified, several spinoff papers appeared some years later (for example, 4.13).

Since 20 years had passed since the founding of the Laboratory, several of the NSMRL psychologists apparently thought it was time to "regroup", that is, to assess where we had been in order to more effectively chart the Laboratory's course in the future. For example, one paper integrated the voluminous data bearing on the validity of the Farnsworth Lantern to screen out severe color defectives from the input submariner oppulation (4.14). Similarly, an intensive navy-side workshop was organized at NSMRL to evaluate some of the new computerized and other approaches to the problem of personnel selection and screening of candidates for hazardous duty. The proceedings of this week-long meeting (4.15) contained a number of suggestions for expanding and redirecting several of the USN selection programs including the submariner program.

Several papers published during this period reflected a renewed concern for specific classes of stressors unique to the submarine environment. For example, following the issuance of the Surgeon General's report on the

hazards of cigarette smoking in 1964, questions were being raised by several congressmen's constituencies as to the possibility of untoward carcinogenic and cardiopulmonary effects of breathing the combustion products of tobacco in an autoclave-tight vehicle (the sub) for 60 to 70 days. Assuming that the tobacco smoke produced by the 75% of the crew who smoked did indeed pose a significant health hazard for the total crew, smokers and nonsmokers alike, during long patrols, one study (4.15) yielded data showing that if smoking were entirely eliminated on submerged subs as it is on most submarines of other nations, the major effect would be subjective. That is to say, the heavy smokers, during the withdrawal period at least, would most likely show adverse emotional reactions such as elevated anxiety and quite possibly, for some men, considerable performance degradation.

1969-1972

The research output of the NSMRL psychologists during this time span indicated that four rather sharply delineated areas were of concern. These were as follows: (1) human factors aspects of submarine escape; (2) psychophysiological effects of long-duration exposure to active sonar "beeps" at high intensity; (3) search for Central Nervous System (CNS) indices of the narcotizing effects of exposure to compressed gases; and (4) drug abuse in the submarine service.

First, while a highly classified fact, the maximum depth capabilities of SSBN's and SSN's was implied in the open newsprint as being at least 250% greater than the 250-foot "test depth" of the WW II diesel submarine. In addition to the tremendous increase in the depth capability of nuclear submarines, the real impetus for submarine escape research resulted from the fact that by the onset of 1969, two USN nuclear submarines, the Thresher in 1963 and the Scorpion in 1968, had been lost at depths measured in miles. Recognizing the timeliness of research questions related to submarine escape, the Human Factors psychologists planned and implemented a series of five

studies (the first in 1970), (4.21) aimed at assessing the relationship of several variations in the design of escape trunks with the egress time of submariners.

The second applied question, namely the behavioral effects of long exposure to high-intensity, sonar beeps was approached again in a multi-disciplinary format involving perceptual, human factors and personnel psychologists (4.22). Based upon data collected from 10 submariners confined 24 days to intermittent sonar beeps at 85 decibels, the findings of this family of studies provided valuable insights into the possible long-term consequences for humans exposed to active sonar searches conducted in this intensity range.

A third research focus initiated during this time frame had to do with the search for an objective indicator of the degree of narcotization resulting from the exposure of Navy divers to several pressurized gas mixtures. In this context, NMRL psychologists specializing in vision, "hit upon" the possibilities of the Visual Evoked Response (VER) as a useful index of the effect (4.23). Improvements in technique for measuring VER as well as validation data bearing on its predictive power were presented in a series of papers published during the next 7 years.

Finally, in July 1971, an important instruction was issued by the Chief of Naval Operations, Admiral Zumwalt. This instruction granted amnesty and guaranteed treatment for any Navy man who admitted habituation to any controlled drug or other substance. Labelled Z-gram 94, this instruction resulted in significant numbers of submariners seeking rehabilitative therapy in the CAACs (Counseling and Assistance Centers) established in the major naval activities. Similarly, several of the NSMRL psychologists, in particular those with a more clinical bent, conducted several studies (4 of them to be precise) aimed at delineating the causes of drug abuse (DA) in the submarine service. For example, one study compared the MMPI (Minnesota Multiphasic Personality Inventory) test score profiles of submariners with a DA history with a control group. The results served to

identify two test score patterns within the DA sample, one of which tended to separate the treatable DA cases from those considered less amenable to short-term therapy (4.24). The philosophical underpinning for all of the DA research at NSMRL held that there is no drug problem in the submarine service but rather a "people" problem (and a small one at that, i.e., less than 20 per thousand), emphasizing that the core research issue is the psychopathological motivation associated with a man's incapacity to cope with the demands of the submarine environment without maladaptive drug usage.

1973-1975

This period of NSMRL history is marked by a number of smaller studies sharply focussed on specific problem areas. For example, in the auditory field, one study centered on the question of speech intelligibility as a method for audiological assessment of naval personnel. This study also touched on the question of techniques for improving the intelligibility of so-called helium speech, the "Donald Duck" voice sounds occurring when men, Navy divers for example, are exposed to pressurized gaseous mixtures of helium and oxygen (4.31, 4.32).

Still working in the diver research area, the NSMRL vision psychologists during this time frame conducted a psychophysical study dealing with the visibility of various colors of underwater targets for active SCUBA divers (4.33). The findings from this line of research turned out to be highly relevant for U. S. Navy SCUBA divers called up to troubleshoot a faulty screw, a propeller shaft seal, or a sonar transducer while the submarine is submerged.

Noted intermittently in this historical account covering 33 years were examples of the age-old "drunkard's paradox" as it applies to research program development. The drunkard's paradox of course refers to the story of the badly-mashed drunk in Central Park who, in the wee hours, was confronted by an Irish cop with the query of why he was on his hands and knees in his helpless condition, feeling the grass under a bright street light, as if looking for something. The drunk, in a typical dipsomaniacal voice, stated that he had lost his watch. "Where did you lose it?" asked the cop. "Over there in the bushes", was the reply. "But why are you

looking for it here?" With complete conviction, the retort was, "This is where the light is!" That is to say methodological developments often dictate which research questions are addressed. For example, the dutchman Zacharias Janssen's discovery of the compound microscope led to tremendous advances in bacteriology and microbiology. Too, Pavlov's discovery of the classical (respondent) and Skinner's discovery of the instrumental (operant) conditioning paradigms provide the methodological bases for the modern Behavioral Modification procedures used widely in psychiatric clinics throughout the world.

Two examples of this philosophy in operation, albeit focussed on the methods development phase of the "methods-to-research" causal sequence, occurred at NSMRL during this period of history. The first example had to do with the development of performance tests of sufficient sensitivity to detect and gradate in terms of intensity the behavioral changes occurring in divers confined in experimental chambers to pressurized gases of various mixtures (4.34). These performance tests, developed and validated by the Human Factors Division of NSMRL, have been shown to have important heuristic value, that is they have provided the methodology and hence the impetus to conduct research into the causes as well as possible prophylactic measures for compression sickness (nitrogen narcosis or rapture of the deep) as well as decompression sickness (bends or Caisson's disease).

The second example was a research project aimed at the development of a simple technique, capable of use by a clerk-typist, whereby cut-off points in a test score distribution (a submariner selection aptitude test, for example) could be identified in such a way that both false positives (rejecting effective men) as well as minimizing false negatives (accepting poor submariner risks) could be minimized, while, at the same time, maximizing the success ratio, i.e., the proportion of submariner candidates accepted for training who do in fact, adapt optimally to the submarine environment (4.35). As with the diver performance tests discussed above, the ECOPs (Experimental Cut-Off Points) that have been calculated and applied in the context of the Submarine School in New London have served (as the light in the drunkard's search) to stimulate more concentrated research in the diver and submariner selection areas.

In addition to the briefer, more focussed studies reported in this period, a very important workshop hend at NSMRL in November of 1974 should be mentioned. While involving submarine researchers of many disciplines besides psychologists, the 3-day meeting served tc integrate the widely scattered information on submarine escape and survival (4.36). As a result of the findings from this workshop, future research planning in this vital area became more sharply focussed with a meaningful prioritization of the various research subareas agreed upon by the panel of international participants.

NSMRL - The Submarine Psychology Program in the Immediate Past (1976-1979)

The peak in the DOD funding for R&D generally and for biomedical research in particular came in the middle to late sixties. During this time frame, a persistent research question which appeared in the early sixties with the launching of the nuclear missile submarines, (SSBNs, called "boomers" by the submariners), reappeared again in the mid-seventies. Quite possibly exacerbated by the carcinogen "witchhunt" underway at that time, the question simply put had to do with the odds that submariners confined for months to a sealed chamber would develop disproportionately more illnesses of all kinds, cardiovascular, respiratory, neoplastic or whatever.

The possible etiological factors for these morbidity patterns were thought to be atmospheric toxicants, absence of sunlight, restricted space and perhaps many others. Accordingly, a detailed analysis of the sick log data from 564 SSBN patrols (60 days average duration) showed among other findings that the virulency of airborne pathogens became negligible after 2 weeks submerged. Tendency to exonerate submarine atmospheric toxicants as a major class of etiological factors, were the findings that the incidence of upper respiratory, gastrointestinal and psychiatric illnesses was higher on the average prior to submergence than during the submerged patrols (5.1).

Shortly after WW II, a paper in the open literature reported an incredibly low incidence of psychiatric casualties occurring in the U. S. submarine service during that conflict, namely, of the order of 0.4 cases/1000. Since then other

estimates of incidence rates for this branch of the service ranged from 4 to 42 per 1000. Perhaps it was this very favorable incidence statistic as compared to the same figure, navy-side, (71/1000) that lulled the NSMRL clinical psychologists into a state of relative non-action in terms of psychopathological research during a span of 20 years or so (references cited in 5.2).

This hiatus in research production in this critical area was broken during this period by two studies published in 1979, one dealing with the incidence and classes of psychiatric disorders occurring in underway nuclear submarines (5.2) and the other with the development of normative psychodiagnostic test score profiles defining the mentally healthy submariner (5.3).

Triggered off mainly by the footage carried in the press about possible carcinogenic effects of shipyard workers being exposed to low-level radiation, the Longitudinal Health Study (LHS) initiated more than a decade before, received renewed attention during this period. The overall objective of this "new look" LHS was to ascertain if indeed disproportionalities between nuclear submariners and non-submariners in the prevalence of a wide range of illnesses (cancer included) could be found. To accomplish this goal, a collaborative effort with highly-trained Yale University epidemiologists and NSMRL scientists was launched at this time. While strictly speaking the epidemiology of organic disease did not directly involve NSMRL psychologists, it became increasingly obvious that the problem of obtaining and sustaining an adequate sized volunteer pool of qualified candidates for submarine duty was closely associated with the public's (including selected congressmen's) attitudes toward the health hazard aspects of the nuclear submarine. Enter NSMRL psychologists into the field of submarine epidemiology!

Mentioned here and expanded somewhat in the final section of this paper is a brief account of the entry of selected segments of the NSMRL staff into the field of cold weather research, specifically as related to the adaptation problems of U. S. Marines assigned to combat duty in extremely cold environments.

One exploratory study, with at least heuristic value, involved an analysis of the attitude change patterns found in 3 marines assigned to a cold weather combat exercise in Norway in early 1979 (5.4). The findings suggested several hypotheses as to the personality types (defined largely by MMPI patterns) likely to show high and low Cold Coping Capacity (CCC).

A LONG LOOK AT THE PAST, A GLANCE AT THE PRESENT AND A GLIMPSE OF THE FUTURE*

A Long Look at the Past

While a somewhat hit-and-miss chronology, we have attempted to develop what may be described as a new field in American Psychology, namely, Submarine Psychology. Analagous to Aviation Psychology, Submarine Psychology focuses upon but is not restricted to behavior occurring in the singularly unique environment of the deeply submerged nuclear submarine.

Whereas a considerable amount of contractual research dealing with submarine-related psychological problems (e.g., development of trouble-shooting manuals for sonarmen), by far, most of the psychological research has been and is being conducted by the staff of the Naval Submarine Medical Research Laboratory (NSMRL). The "tone" of this sketchy chronology of Submarine Psychology at NSMRL has been one of attempting to demonstrate the interrelationship of the research requirements of the operational submarine fleet and the scientific production of the NSMRL staff psychologists over the past 33 years of the laboratory's existence.

But how is research production to be measured? In the early sixties, the Harvard Business School published the results of a rather comprehensive study designed to identify early in the adolescent years predictors of the choice of careers in some one or another of the scientific disciplines. An additional related goal of this longitudinal study was not only to predict career choice but also to delineate predictors of individual differences in the quality of scientific output within the population segment who eventually become fully-trained scientists. While clearly admitting the inadequacy of a simple count of publication titles as a criterion of scientific production, the authors of this study failed to find a more adequate evaluation standard.

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* This chronicler, perhaps unjustifiably, as a retired NSMRL staff clinical psychologist and Head of the Personnel Assessment Division of the Laboratory for more than 27 years, has assumed the prerogative to introject some opinions from time to time in this segment of this paper.

Accordingly, the herculean task of counting the publication titles * of NSMRL Laboratory Reports (LR) and NSMRL Memorandum Reports (MR) was completed and the results plotted in 3-year intervals in Fig. 3. Some rather obvious broad impressions from the bargraphs in Fig. 3 follow. Following its establishment in 1946, the NSMRL staff of psychologists increased in numbers from 16 to 30 (87%) by the time Nautilus was launched in 1954, stayed approximately level until 1969 after which the number of psychologists dropped off about 25%. With the exception of the '66-'69 time frame, from 60 to 80 percent of the psychological staff were involved in research in the vision or auditory areas. Not suprisingly, the research output as measured by publication counts has correlated positively with staff size over those 3 decades.

Retired U. S. Navy Medical Corps Captain Charles F. Gell, who held the position of Scientific Director of NSMRL from 1967 to 1975 often repeated an expression to indicate his opinion of the control mechanisms of Department of Defense (DOD) R&D (Research and Development). An embellishment on the Golden Rule, the expression went "He who has the gold rules". Accepting this premise, in the context that almost 90% of a given DOD laboratory budget ** is equated to salaries, one can gain an impression as to the assumed priorities of the

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*This task was completed unassisted by Mrs. Teresa F. Smith, Editor, NSMRL. The criteria for classifying a paper as either an LR or MR are spelled out in an official NSMRL Instruction, 5720.1. Briefly, a Laboratory Report (LR) is generally a report of a scientific experiment which, in most cases, has been published in a refereed, professional journal. In contrast, a Memorandum Report (MR) is subject only to in-house review and may contain a variety of content such as a new laboratory or statistical technique, a speech delivered to a professional society or a new theoretical formulation.

**An illustration of the phenomenal rise in the cost of R&D in the DOD is found in a comparison of the FY '47 budget of 100K and the FY '79 budget of 2.1 million. Corrected for inflation this represents an increase of about 825%. Without the correction for inflation the increase is of course much more, of the order of 2000%.

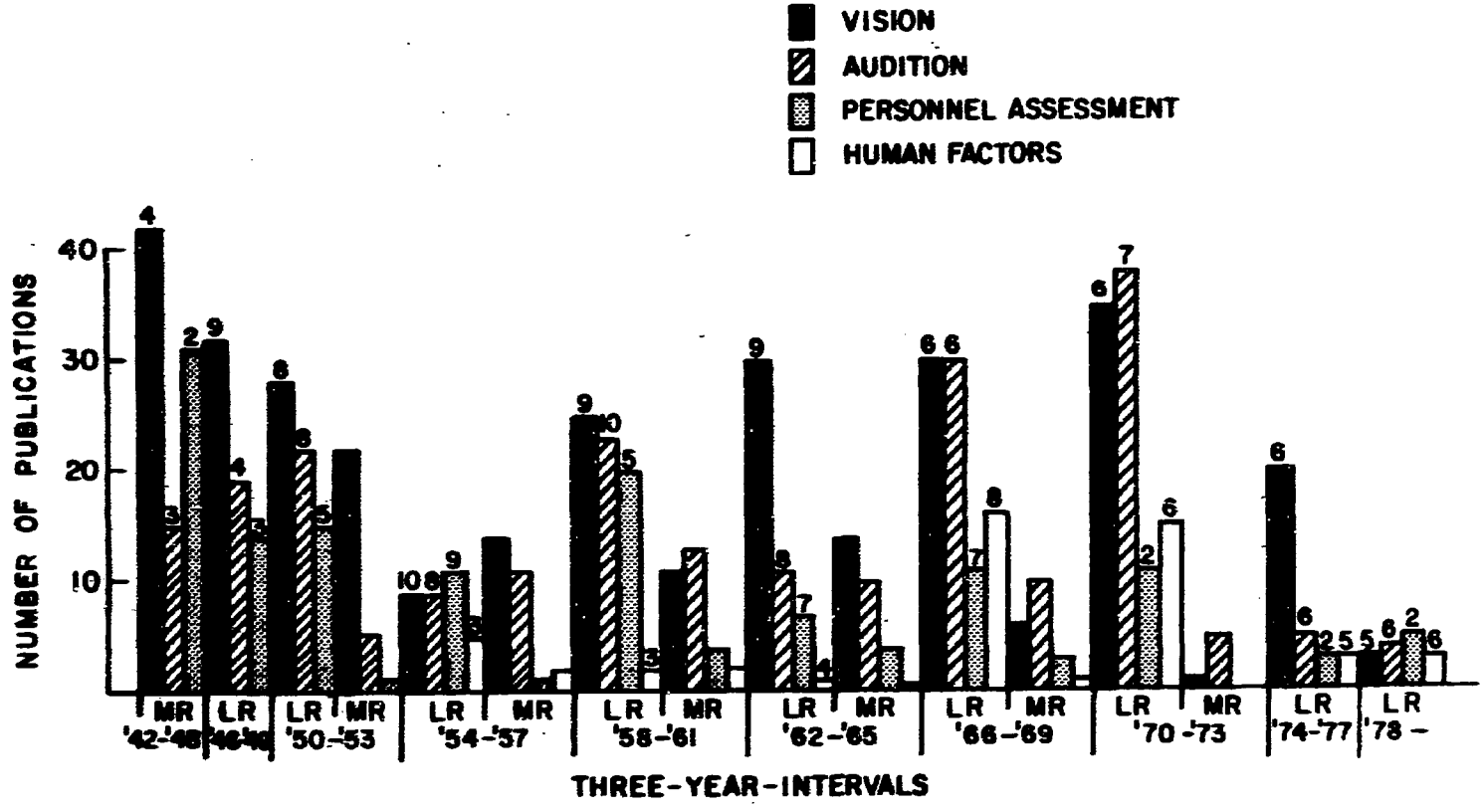

Fig. 3. Number of NSMRL Laboratory Reports (LR) and Memorandum Reports (MR) published in 3-year intervals. The numbers above the bars indicate the number of psychologists (PhD's, MA's and BA's, both civilian and military) on the NSMRL staff at that time.

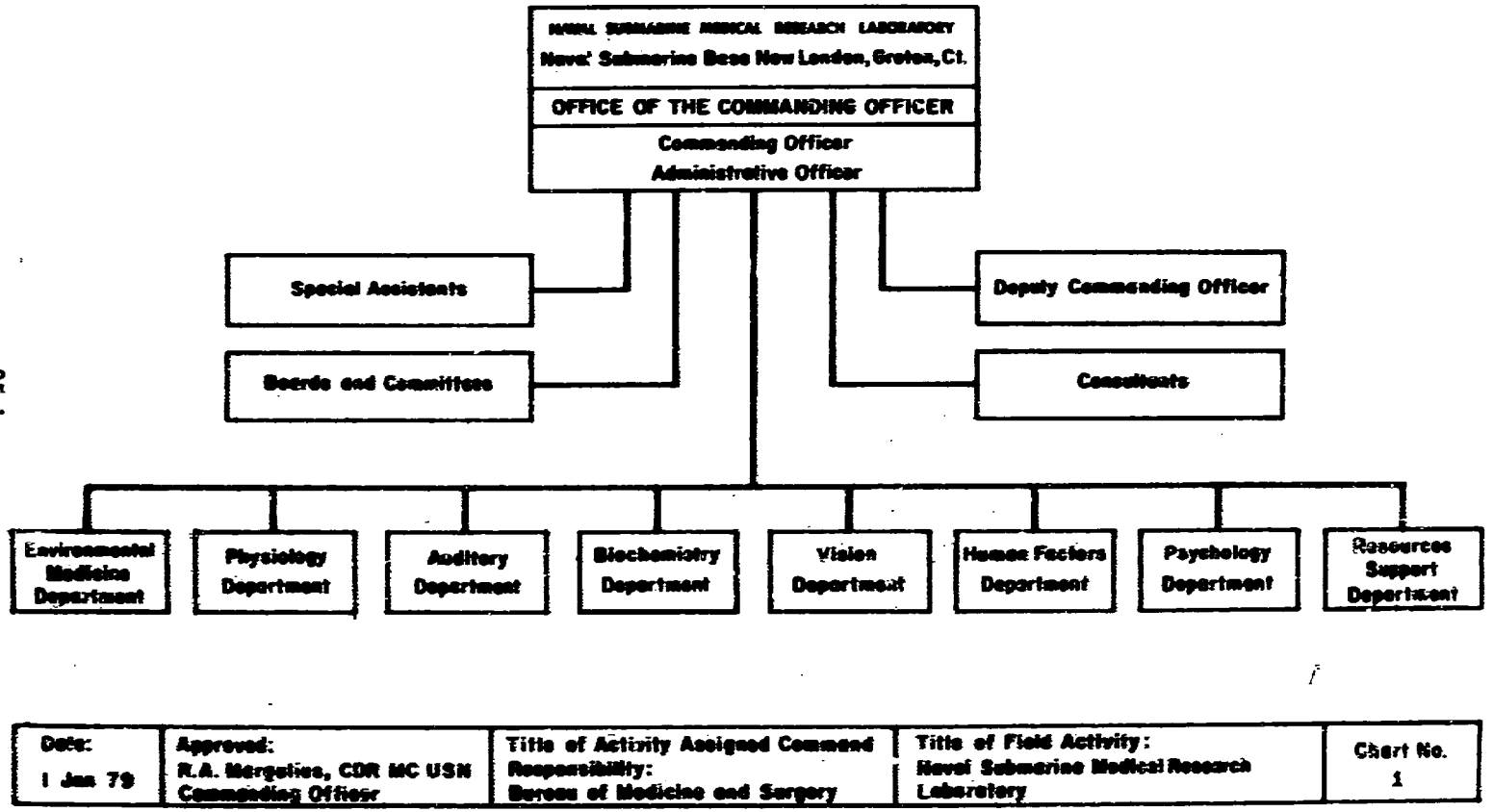

Fig 4. The Naval Submarine Medical Research Laboratory Organizational Chart in 1979.

R&D planners controlling in-house laboratory programs over a given time span. Returning to the bargraphs in Fig. 3 for example, vision and auditory research apparently has been and still is viewed as the most relevant, psychological research area related to the requirements of the "sub" service. A close second in terms of funding is Human Factors research, which in terms of staff size has increased more than 100% since its beginning in the late fifties. Conversely, based again upon staff size, personnel assessment which constituted the first NSMRL research effort (deck and sonar watchstander selection) in WW II reached its peak in the '54-'57 period (staff of 9 psychologists/psychiatrists) only to decline 70% in the early seventies to a staff of 2. Apparently this disproportionate decrease in resource support for personnel psychological research at NSMRL reflects either that the management of NMRDC (Naval Medical Research and Development Command)* has made the decision that this type of research has very low priority or that the research production by this small group of psychologists over the last 30 years has served to answer, or partially answer at least, most of the submarine-relevant questions in this area.

One final observation concerning the bargraphs in Fig. 3 should be mentioned. Since the middle to late sixties, the use of Memorandum Reports (MR) as a medium for recording miscellaneous research-related items has declined remarkably. In fact no MRs have been published since 1974. This observation may reflect the ever-accelerating peer pressure exerted upon researchers generally to publish papers only in widely circulated, and it might be added, very expensive professional journals.

A Glance at the Present

Figure 4 presents the current (1979) structural chart of NSMRL. While only 4 psychologists were considered the official NSMRL plank owners (Appendix B), a staff of 16 psychologists were recruited by the end of the first year of NMRL's existence, in FY '47. At present, the NSMRL staff psychologists number twenty (Fig. 3). As was

*Located geographically at the National Naval Medical Center, Bethesda, MD., NMRDC was established as an R&D Command in 1974.

the case in the original structural chart (Fig. 2), the auditory and vision departments are among the largest in terms of staff size, approximately equal to the relatively new Human Factors Department established in the late fifties (Appendix B). Fig. 4 shows a fourth department, the "Psychology Department" with a staff of 3 psychologists (Appendix B). The program of this department is essentially equivalent to the "Personnel Selection Facility", similarly with a staff of 3 psychologists, that was included in the original NMRL structure (Figs. 2 and 3).

The relationship between technological advances and foci of research in submarine psychology, repeatedly pointed out as this historical writing unfolded, is clearly seen in the present (1979) sonar developments area. In the past, sound-emitting objects in the water such as surface craft (skimmers in submarine jargon), submarines, and sea animals of all kinds have been identified and classified largely by auditory information even though the sound spectra were visually displayed on a cathode ray oscilloscope.

However, the modern sonar system, for example the Improved Sonar Processing Equipment (ISPE) installed on some of the later SSBNs (Nuclear Missile Submarines) is truly biomodal in terms of sensory input, with visual and auditory information being integrated and processed by computer to yield highly accurate object identification and classification data to be used by the sonar operator as a basis for his decision making. In order to optimize the interfacing conditions existing for the sonarman in this advanced system, the Human Factors, Vision and Auditory psychologists at NSMRL are at present engaged in a "mini-all-hands" evolution to answer the pertinent research questions upon which the effectiveness of the system depends.

At present (FY '79) the psychological research program of NSMRL has been somewhat diverted, temporarily it is presumed, away from a focussed attack upon the psychological problems still existing within the Submarine Service. This oblique focus is upon cold weather research as required to enhance the effectiveness of combat marines assigned to duty in extremely cold environments. The NSMRL psychologists are preparing to investigate such research problems as the visual

processes associated with the "white out" phenomenon, the psycho-ecological factors involved in cold weather injury and morbidity, effects of extreme cold on hearing, the human factors design of cold weather casualty evacuation equipment, and the development of effective psychological screening methods to identify men with maximum cold coping capacity (CCC).

A Glimpse of the Future

Selected conclusions from two, broadly-focussed planning conferences on submarine research would appear to provide a basis for predicting the directions most likely to be taken in the future. The first of these conferences was the 2-week meeting of the Submarine Habitability Panel, of the Defense Research Group (DRG) held during the NATO exercises in Coblenz, W. Germany in November of 1972. Of the 8 or 10 research goals or objectives emerging from this 12-member, 5-nation meeting, the two top priority items were in the same order, (1) the identification and control of the major toxicants in the submarine atmosphere and (2) the development and validation of effective psychological screening methods for submarine personnel.

Two spinoffs came from the rather lengthy discussions of these two topics at the NATO exercises. First, recognizing the need for an objective criterion for gauging the psychological effects of various classes of submarine stressors, the panel developed, and to an extent, attempted to apply the concept of "Significant Adaptive Decrement" (SAD). Analagous to LD_{50} (Lethal Dose in 50% of the exposed population), used in pharmacology, SAD_{50} refers to the intensity of a stressor class (e.g., level of a toxic gas, length of duty cycle, duration of sleep deprivation, etc.) that results in a SAD in 50% of the crew.

A second spinoff, actually an R&D management "tool", was the development of a format made up of 9 dimensions with respect to which R&D planners could rate a given research proposal. A payoff probability statement could be obtained by the use of this technique, thus providing some semblance of objectivity for the formidable task of prioritizing an array of R&D proposals. Whereas the specific recommendations of the DRG were published as NATO confidential, one summary paper in the open

literature and written for these meetings alludes to many of the discussion topics included in the agenda for those meetings (reference IIIC in Additional Bibliography Section).

The second broad-scope conference that appeared to point the way in submarine research was the week-long meeting of the Technical Working Group (TWG) at NSMRL in November of 1975. The participants consisted of Submarine Line Commanders, Submarine Medical Officers, and civilian scientists. The end product of the conference was a rank ordering of the research problem areas considered most critical for the future of the submarine service (reference IIID in additional bibliography section).

Similar to the recommendations of the NATO DEG panel, the TWG list of priorities placed research in the toxicology of the submarine atmosphere and research in submariner selection in that order at the top. One clear, underlying trend in the TWG panel discussions was a renewed emphasis in preventive psychiatry and psychology within the submarine service. Stated simply, it may be more important to conduct the research necessary to develop techniques for maintaining resilient mental health during long submerged missions than for identifying the major etiological factors involved in the psychopatholoty and performance degradation occurring at times under the same conditions.

There are at present about 106 operational nuclear submarines in the U. S. Submarine Fleet, 41 SSBNs and 65 SSNs. Diesel submarines have become obsolete. Table 1 depicts the relative sizes of the various classes of nuclear submarines commissioned since the middle fifties. Relative crew sizes are also indicated.

Along with the changes in crew size, displacable volume and fire power of the submarines of the future comes the possibility of another change, this time in terms of one aspect of the submarine support system. U. S. Navy nuclear submarines tied to one of the Fleet's few submarine tenders has been likened to parasitic plant life clinging to its host. Submarines, nuclear or non-nuclear, characteristically are to a great extent dependent upon the huge, 1000-crew tenders for repairs, parts and supplies. But a large surface craft such as the tender which

Table 1

Comparative Data for Different Classes of Submarines of the U. S. Fleet

Submarine	Type	Vital Statistics		Crew size		Number Missiles
		Length (ft)	Displacement (tons)	Officers	Enlisted	
WW II Diesel	Attack	300	3200	9(12%)	64(88%)	--
NAUTILUS	Attack	320	3200	14(12%)	100(88%)	--
TRITON	Attack	447	5900	15(10%)	126(90%)	--
SSN (Sturgeon Class)	Attack	292	4000	12(12%)	88(88%)	--
SSBN	Fleet Ballistic Missile	426	7000	16(11%)	124(89%)	16
TRIDENT	Fleet Ballistic Missile	560	18,000	16(10%)	148(90%)	24

provides such a vital link for submarine operations, is a highly vulnerable target for surface or air missiles and bombs. Tenders cannot be effectively concealed. But a submersible tender with the parasitic nuclear "subs" married to it for refitting with the total complex submerged at 100 fathoms or so would be very well concealed from enemy attack weapons of all kinds. And, in this context, the NSMRL psychologists who for the past decade or so have been conducting research in the area of U. S. Navy diver adaptability, will be able to use their data base as a platform from which to launch new research probes into the psychophysiological problems of atmospheric pressurization and decompression.

Does the information in Table 1 suggest any probable trends in the research and other activities of Submarine Psychologists of the future ? In the late fifties and early sixties an NSMRL ad hoc panel was tasked to prognosticate the kinds of research questions that would arise if SUBIC (Submarine Integrated Control) would become, as its developers predicted, the one single Central Data Processor (CDP) for the weapons, navigational and control systems of the submarine. If SUBIC would have been successful, the required size of the SSBN crews would have been reduced, it was predicted, by about 85%, to 3 sections of 7 men each, a total crew of 21 submarine officers and enlisted men. But, apparently because of unsurmountable man-machine interfacing problems, SUBIC as a total system, never reached its fulfillment. As a result, instead of decreasing, the total crew size of the SSBNs (Table 1) increased by about 23% as compared to the largest attack class submarine, the Triton. Further, the crews of the TRIDENT, now under construction, are programmed to increase in size only 16% while the fire power (number of nuclear-armed missiles) will increase 50% which is about the same proportionate increase in displacement weight (Table 1).

This disproportionate increase in the size and fire power of the "subs" of the future as compared to crew size most likely reflects an obvious fact, namely, that the technological age of modular or integrated circuitry electronics and mini-, even micro-computers, is upon us. It has been somewhere between 80 and 90

years since Herman Hollerith introduced the punched card as a data storage mode. Since WW II, electronics technology has progressed from electron tubes, through transistors to pea-sized integrated circuits. Similarly, in the computer sciences the progression has gone from the 80-column punched card with 80 bytes of storage capacity processable by a card sorter operating at a rate of 120 cards/minute to the modern batch processor with storage capacity in the 50 to 192 kilobyte range with many data processing tasks accomplished in a matter of 10 to 1000 nano (billionth) seconds.

For submarine psychologists, this space age technology may suggest that the image of an ET (Electronics Technician) circuit testing with a soldering iron in his hand and a QM (Quartermaster) operating a slide rule to calculate the SOA (Speed of Advance) of a submarine will soon exist only as memories. Different aptitudes and perhaps average vice the present high average to superior functional intelligence will constitute the personnel selection criteria of the future. Longer submerged missions, 5 months or more for example, more square footage of deck space per man, and vastly improved "hotel accomodations" for the submariner of the future may introduce a whole set of critical research areas. Mostly social psychological in nature, some of these might be territoriality, the dynamics of clique formation, attitude change, and role incongruency, and a new look at the psychology of boredom. Of course, these psychosocial problems existed on the old gasoline-powered Skipjack launched in 1911 as well as on the new nuclear-powered Skipjack launched almost 50 years later. The circumstances were however, that the NSMRL psychologists were not present at the first launching and, following the second launching, as this chronicle attests, they have been somewhat technologically constrained in their choice of research problems. Assuming that submarine technology may have at least temporarily reached a plateau, it may be that in the future the submarine psychologists on the staff of the Naval Submarine Medical Research Laboratory can begin to target research problems more uniquely associated with a submariner's quality of life day-in-and-day-out during extended submarine patrols.

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*Except for the authors' names for a representative sample of publications predating the establishment of NMRL, the authors' names are omitted. This is to avoid overlooking deserving authors in the interest of brevity.

**AD numbers are the document access numbers for retrieval in the computer storage of the Defense Documentation Center, Cameron Station, Alexandria, VA., 22314

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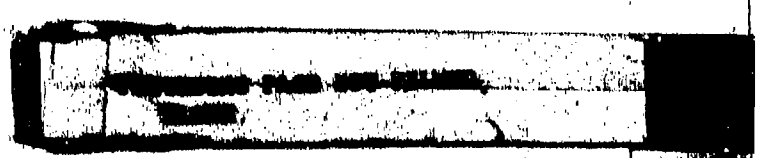

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Officers in Charge (O-in-C), Directors or Commanding Officers (CO) and Scientific Directors of the U. S. Naval (Submarine) Medical Research Laboratory

CAPT Charles W. Shilling, MC, USN	O-in-C	Jun 24, '46 - Sep '47
CAPT Thomas L. Willmon, MC, USN	"	Sep '47 - Aug '51
CDR Gerald J. Duffner, MC, USN	"	Aug '51 - Sep '56
CAPT Joseph Vogel, MC, USN	"	Sep '56 - May '59
CAPT George F. Bond, MC, USN	"	May '59 - Jun '64

The Naval Submarine Medical Center was established in July '64 with a Commanding Officer who was in charge of three departments, namely the Hospital (clinical services), the Submarine Medical Research Laboratory and the School of Submarine Medicine. *

Directors of the Medical Research Laboratory

CDR Earl H. Ninow, MC, USN (acting) (part-time from BuMed, 2 days per mo)	Jul '64 - Nov '64
CAPT Walter F. Mazzone, MSC, USN (acting)	Dec '64 - Jul '65
LCDR Paul G. Linaweaver, MC, USN	Oct '65 - Feb '66
CAPT Jack L. Kinsey, MC, USN	Feb '66 - Jul '67

There was an interval (Jul '67 - Aug '68) when the Laboratory was without a Director and the Scientific Director was acting.

CDR Joseph D. Bloom, MC, USN	Aug '68 - Jul '72
CAPT John H. Baker, MC, USN	Jul '72 - May '73
CDR Raymond L. Sphar, MC, USN (acting)	Jun '73 - Jul '73
CDR Raymond L. Sphar, MC, USN	Jul '73 - Jun '78 **
CDR Robert A. Margulies, MC, USN	Jun '78 - present (Oct '79)

Scientific Directors

Walter R. Miles, Ph.D.	1958 - 1966
Charles F. Gell, (MC) USN (Ret) D.Sc.	1966 - 1975

* While the Naval Submarine Medical Research Laboratory was under the command of the Naval Submarine Medical Center, the Center's Commanding Officers were:

CAPT Charles L. Waite, MC, USN Jul 64 - Aug '67
CAPT Jack L. Kinsey, MC, USN Aug '67 - Nov '67
CAPT Gerald J. Duffner, MC, USN Nov '67 - Apr '69
CAPT James E. Stark, MC, USN Apr '69 - Aug '73
CAPT Vernon A. Burkhart, MC, USN Aug '73 - Dec '74

** On July 1, 1974, the Naval Submarine Medical Research Laboratory became its own Command and on 5 Dec 1974 the Officer in Charge of the Laboratory became the Commanding Officer.

Psychologist Staff Members at the time the Naval Medical Research Laboratory was established -- June 24, 1946:

Staff Member	Area of Specialization
J. Donald Harris, Ph. D.	Audition
N. R. Bartlett, Ph. D.	Personnel Selection
W. S. Verplanck, Ph. D.	Vision
CDR D. Farnsworth, (MSC) USN	Vision

Staff Psychologists of U. S. Naval Submarine Medical Research Laboratory, June 1979:

Vision Department

J. A. S. Kinney, Ph. D., Director
S. M. Luria, Ph. D.
C. L. Schlichting, Ph. D.
H. M. Paulson, B. A.
Alma Ryan, B. A.

Auditory Department

J. Donald Harris, Ph. D., Director
J. E. Kerivan, Ph. D.
P. G. Lacroix, M. A.
J. S. Russotti, M. S.
P. F. Smith, M. A.

Human Factors Engineering Department

G. Moeller, Ph. D., Director
A. N. Beare, LT (MSC) USN, Ph. D.
B. L. Ryack, Ph. D.
K. V. Laxar, M. A.
K. D. Robinson, B. A.
W. H. Rogers, M. A.

Personnel Selection Department

B. B. Weybrew, Ph. D., Director
L. M. Dean, LT (MSC) USN, Ph. D.
E. M. Noddin, B. A.

Computer Applications Division

Thomas P. Santoro, Ph. D.

Table 2
Advanced Degrees or Certificates Earned by Staff Psychologists by Means of Dissertation or Thesis Research Conducted at NSMRL

Department	Academic Degrees			Submarine Med. Theses
	PhDs	Masters	Bachelors	
Auditory	7	16		1
Human Factors		1		
Personnel Research	3	1	1	5
Vision	2			

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	6. PERFORMING ORG. REPORT NUMBER: NSMRL Rpt. 917
7. AUTHOR(s): Benjamin B. WEYBREW, Ph. D.	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Submarine Medical Research Laboratory, Box 900 Naval Submarine Base, Groton, Connecticut 06340	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Medical Research and Development Command, National Naval Medical Center, Bethesda, Maryland 20014	12. REPORT DATE: 23 October 1979 / 13. NUMBER OF PAGES: 45
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submarine psychology; submariner selection; vision; hearing; human factors; history of psychology; nuclear submariners

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Largely mandated by the operational requirements of the diesel submarine service of WW II, considerable psychological research in the areas of hearing, vision and personnel selection was conducted prior to the official establishment of the Naval Medical Research Laboratory (NMRL) on June 25, 1946. During the first decade of NMRL, the original staff of 9 psychologists doubled in size while producing some 80 scientific publications dealing largely with sonarmen's performance, visual problems

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of submariners and various aspects of the submariner selection problem. With the launching of NAUTILUS, the first atomic-powered submarine in 1954, the nuclear era brought many new psychological problems associated with the increase in the duration of submerged patrols from 3 to 80 days or more. Psychopathological effects of isolation, increased auditory and visual skills requirements, and a host of human factors problems associated with complex nuclear technology are examples of the content of the some 550 papers published by the NSMRL staff psychologists in the fifties and sixties. Based upon a presumed leveling off of advancements in nuclear submarine technology, changing research foci in the psychological program at NSMRL are predicted. One trend thought likely is for less focussed work in the areas of auditory and visual perception and more emphasis upon matters related to the psychiatric screening of submariner candidates as well as investigative efforts to discover new approaches for the prevention of morale deterioration, performance decrements, and in some cases, debilitative psychopathology in submarine crew members during long submerged missions.